(19) Europäisch s Pat ntamt
Europ an Patent Office
Offic urop´en d s brev ts

(11) EP 0 978 370 A2

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**09.02.2000 Bulletin 2000/06**

(51) Int Cl.⁷: **B29D 30/06**, B29C 35/02

(21) Application number: **99306074.8**

(22) Date of filing: **30.07.1999**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE**
Designated Extension States:
**AL LT LV MK RO SI**

(30) Priority: **03.08.1998 JP 21910298**

(71) Applicant: **SUMITOMO RUBBER INDUSTRIES LTD.**
**Hyogo-ken (JP)**

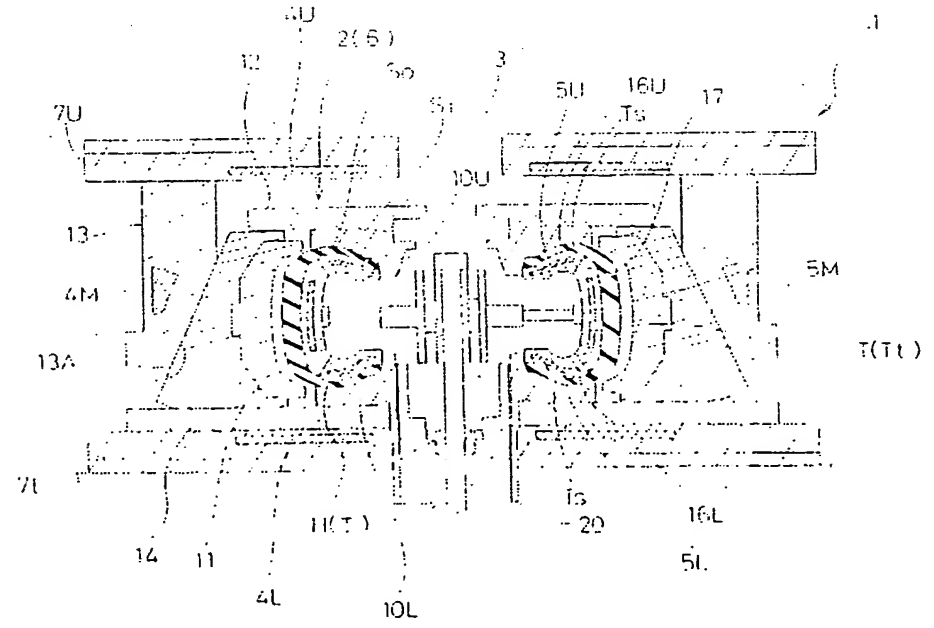
(72) Inventor: **Kobayashi, Michihito**
**Toyota-shi, Aichi-ken (JP)**

(74) Representative: **Stewart, Charles Geoffrey**
**Technical,**
**Dunlop Tyres Ltd.,**
**Fort Dunlop**
**Erdington, Birmingham B24 9QT (GB)**

## (54) Vulcanising method and vulcanising apparatus for a tyre

(57) A tyre (T) is vulcanised by heating the tyre (T) from both an outer forming surface (So) of an outer mould (2) and an inner forming surface (Si) of an inner mould (3). The inner forming surface (Si) is divided into a plurality of inner forming surface portions (Si1.Si1.Si2) in accordance with portions of the tyre (T). and the inner mould (3) is provided with heaters (5U.5L.5M) capable of heating the inner forming surface portions (Si1.Si1.Si2) at different temperatures. Since the tyre is vulcanised while varying the heating temperatures from inside of the tyre in accordance with the portions of the tyre. it is possible to vulcanise each of the portions of the tyre under optimal temperature condition without generating uneven temperature between upper and lower portions. and thus to enhance the performance of the tyre.

Fig. 1




EP 0 978 370 A2

## Description

**[0001]** The present invention relates to a vulcanising method and a vulcanising apparatus for a tyre capable of vulcanising a tyre at optimal temperature in various portions of the tyre so as to enhance the performance of the tyre.

**[0002]** In general. when a tyre is vulcanised. as shown in Fig. 5. a vulcanising apparatus is used comprising an outer mould (a) having a tyre forming cavity (a1), and a bladder (b) for pushing a raw tyre (t) against an inner peripheral surface of the tyre forming the cavity (a1). The tyre is heated from the outside by heat transmitted from heaters (h) provided on upper and lower platen plates (c) which is conducted through the outer mould (a). The tyre is heated from the inside by filling the bladder (b) with a high temperature thermal pressure medium (e) and the outside and inside of the tyre are controlled to be at a constant temperature.

**[0003]** On the other hand, characteristics required by different portions of the tyre such as tread portion. side wall portion. and bead portion are different. For example. the tread portion requires grip properties. wear resistance. crack resistance. low febriferous properties and the like so as to provide on contact with the ground transmission of the driving and braking forces. The side wall portion requires flexibility. crack resistance and weather resistance so as to prevent the carcass from being damaged and so that the side wall portion can be bent flexibly. The bead portion requires rigidity. wear resistance and low febriferous properties so that the tyre is fitted and held on the rim. Therefore. different compound rubbers are used for different portions of the tyre for satisfying the individual requirements. Finally. as tyres became more and more sophisticated and the production output became higher in recent years. the characteristics of the compound rubbers are enhanced further.

**[0004]** In order to allow the individual compound rubbers to exhibit the individual characteristics sufficiently. it is desirable to vulcanise the individual compound rubbers at optimal vulcanising temperature.

**[0005]** However. in the conventional vulcanising apparatus. since the outside and inside of the tyre are controlled at a constant temperature. it is difficult to sufficiently exploit the performance of the compound rubber. and the tyre performance is not optimised.

**[0006]** Especially in steam vulcanising heated curing using saturated steam as the thermal pressure medium. or in a gas vulcanising method using a thermal pressure medium which is a mixture of steam and inert gas such as nitrogen gas. steam condensed in vulcanisation tends to be accumulated at the lower side (s2) as condensate (d). or low temperature inert gas and high temperature steam tend to be separated to the top and bottom regions of the bladder (b). As a result. uneven temperature occurs between the upper side (s1) and lower side (s2) of the inner surface of the tyre (t). which promotes deterioration of the tyre performance.

**[0007]** In Japanese Patent Publication JP-A-6-18699. it has been proposed to change the temperature of the outer mould depending upon each of the particular portions of the tyre (tread portion and side wall portion) so as to vulcanise the compound rubber at optimal vulcanising temperature. However. the various portions of the tyre are uniformly heated on the inside through the bladder by the usual thermal medium in the steam vulcanising method or in the gas vulcanising method. and uneven temperature still is generated between the upper and lower sides (s1) and (s2) and therefore. it is difficult to sufficiently optimise the vulcanisation.

**[0008]** Thereupon. it is an object of the present invention to provide a vulcanising method and a vulcanising apparatus capable of vulcanising various portions of the tyre under optimal temperature condition without generating uneven temperature between upper and lower portions. and thus capable of enhancing the tyre performance.

**[0009]** According to a vulcanising method of a first aspect of the present invention. in the vulcanising method for vulcanising a tyre by heating from an outer forming surface and an inner forming surface of a vulcanising apparatus comprising an outer mould having the outer forming surface for forming an outer surface of the tyre and an inner mould having an inner forming surface for forming an inner surface of the tyre. the inner forming surface of the inner mould is divided into a plurality of inner forming surface portions in accordance with portions of the tyre along an outline of a tyre meridian cross section. and temperatures of the inner forming surface portions are varied to vulcanise each of the portions of the tyre.

**[0010]** The outer forming surface of the outer mould may also be divided into a plurality of outer forming surface portions in accordance with portions of the tyre along the outline of the tyre meridian cross section. and the temperatures of the outer forming surface portions are varied to vulcanise each of the portions of the tyre.

**[0011]** According to a second aspect of the invention a vulcanising apparatus for a tyre comprises an outer mould having an outer forming surface for forming an outer surface of the tyre and an inner mould having an inner forming surface for forming an inner surface of the tyre. wherein the inner forming surface of the inner mould is divided into a plurality of inner forming surface portions in accordance with portions of the tyre along an outline of a tyre meridian cross section. and the inner mould is provided with heaters capable of heating the inner forming surface portions at different temperatures.

**[0012]** The outer forming surface of the outer mould may also be divided into a plurality of outer forming surface portions in accordance with portions of the tyre along an outline of a tyre meridian cross section. and the outer mould is provided with heaters capable of heating the outer forming surface portions at different temperatures.

[0013] An embodiment of the present invention will be explained. by way of example only. together with the drawings below in which:

Fig. 1 is a sectional view of a vulcanising apparatus of an embodiment of the present invention:
Fig. 2 is a sectional view showing the state during vulcanising and forming of the tyre:
Fig. 3 is a sectional view for explaining the standby state of the vulcanising apparatus in which an upper platen plate rises:
Fig. 4 is a sectional view for explaining motions of side moulds and segments when the upper platen plate is lowered: and
Fig. 5 is a schematic view for explaining a conventional tyre vulcanising method and apparatus.

[0014] In Fig. 1 various portions of the tyre (shown in Fig. 2) which are side walls Ts and a tread Tt are vulcanised at respective temperature in accordance with its compound rubbers.

[0015] In the drawings. the vulcanising apparatus 1 comprises an outer mould 2 having an outer forming surface So for forming the outer surface of the tyre T. and an inner mould 3 having an inner forming surface Si for forming the inner surface. The tyre T is vulcanised and formed in a tyre forming cavity H surrounded by the outer forming surface So and the inner forming surface Si. In said cavity the tyre is held under pressure and heat is put into the compound to cure it.

[0016] The outer mould 2 includes an outer mould body 6 constituting the outer forming surface So. and heated plate-like upper and lower platen plates 7U and 7L including heaters. The lower platen plate 7L is fixed to a table (not shown). and the upper platen plate 7U is vertically movably mounted to a press (not snown). Thus the platens can be used to close the mould. hold it closed and to supply heat.

[0017] In this example. the outer mould body 6 is of a type which is divided into a plurality of portions in its circumferential direction. and comprises upper and lower side moulds 10U and 10L for forming outer surface of the side walls Ts. and a plurality of segments 11 which are divided in the circumferential direction for forming an outer surface of the tread Tt. When the mould is closed by the platens. each of the divided surfaces of the upper and lower side moulds 10U. 10L and the segments 11 abut against one another. thereby forming a continuous outer forming surface So.

[0018] As shown in Fig. 2. the outer mould body 6 is divided so that the outer forming surface So comprises outer forming surface portions So1. So1 to form the side moulds 10U. 10L corresponding to the side walls Ts of the tyre. and an outer forming surface portion So2 comprising the segments 11 corresponding to the tread Tt. Therefore. the outer forming surface So is divided along the outline of the tyre meridian cross section into a plurality of outer forming surface portions in accordance with different portions of the tyre.

[0019] The segments 11 are slidably held by an inclined linear bearing 13A of an actuator 13 fixed to the upper platen plate 7U The upper side mould 10U is mounted to a lower surface of a disc-like holding plate 12 placed between upper ends of the segments 11 such as to be astride the upper ends. and the lower side mould 10L is fixed to the lower platen plate 7L through a holding plate 14.

[0020] Therefore, as shown in Figs. 3 and 4 as the upper platen plate 7U is moved upward by the press. the segment assembly is increased in diameter so as to separate from the tyre T by means of the segments 11 moving in a radially outwards direction and then. they are moved upwards together with the upper side mould 10U which is placed on the upper ends of the segments 11. When the segments 11 and the upper side mould 10U are moved upwards in this manner. the tyre T can be removed and a new unvulcanised green tyre carcass put in place. In the closed state of the tyre forming cavity H in the lowering motion. the outer mould body 6 closely abuts against the platen plates 7U. 7L through the holding plates 12. 14 and the actuator 13.

[0021] The platen plates 7U. 7L and the actuator 13 are provided with heaters 4U. 4L. 4M comprising electric heaters or steam jackets. Therefore. the outer forming surface portions So1. So1 are heated by the heaters 4U. 4L. and the outer forming surface So2 is heated by the heater 4M.

[0022] The inner mould 3 is a toroidally shaped rigid metal body provided with inner mould pieces 16U. 16L corresponding to the side walls Ts. and a central inner mould piece 17 corresponding to the tread Tt and integrally connected to the inner mould pieces 16U. 16L. Tne inner forming surface Si is formed by an outer surface of the inner mould 3. Therefore. the inner forming surface Si of the inner mould 3 is also divided into a plurality of inner forming surface portions in accordance with portions of the tyre along the outline of the tyre meridian cross section. i.e.. divided into inner forming surface portions Si1. Si1 comprising the inner mould pieces 16U. 16L corresponding to the side walls Ts. and an inner forming surface portion Si2 comprising the central inner mould piece 17.

[0023] In this example. the inner mould pieces 16U. 16L. 17 are provided with electric heaters 5U. 5L. 5M. and the inner forming surface portions Si1. Si1 and Si2 are individually heated.

[0024] The inner mould 3 is vertically movably supported by a supporting shaft 20 extending concentrically with the tyre axis. As shown in Fig. 3. the supporting shaft 20 can be moved upwards to an upper standby position of the platen plate 7U. the raw tyre T is placed around the outer periphery of the inner mould 3. and the inner mould 3 is lowered to

the normal vulcanising and forming position. In the outer mould 2, as the platen plate 7U is lowered. as shown in Fig. 4, a state in which the tyre T is held between the side moulds 10U, 10L is once established and then, the segments 11 are moved radially inwards sliding between the holding plates 12. 14.

**[0025]** At the closed press position of the platen plate 7U. as shown in Fig. 2. the divided surfaces of the side moulds 10U. 10L and the segments 11 abut against each other, the tyre T in the closed tyre forming cavity H is clamped and compressed. thereby allowing vulcanising and forming by the heat and pressure provided.

**[0026]** Here. the vulcanising apparatus 1 and the vulcanising method of the present application are characterised in that the temperatures of the inner forming surfaces portions Si1. Si2 of the inner mould 3 are varied from one another by controlling the heaters 5U. 5L and 5M. and so various portions of the tyre. i.e . the side walls Ts and the treat Tt are vulcanised at different vulcanising temperatures.

**[0027]** Thus in the present application. the vulcanising temperature at which the characteristics of each compound rubber used for each of the portion of the tyre can be effectively selected. and the temperature of each of the portions is controlled by the inner forming surface portions Si1. Si2. Since the present application makes it possible to control the temperature at the inside of the tyre which previously had uneven temperatures between upper and lower portions in the conventional technique. it is possible to vulcanise each of the compound rubbers at more suitable temperature as compared to the processing systems in which the temperature is controlled from outside the tyre.

**[0028]** More preferably. the temperatures of the outer forming surface portions So1. So2 are also varied from one another by controlling the heaters 4U. 4L and 4M. and the tyre is heated from both inside and outside the tyre at temperatures suitable for each of the compound rubbers.

**[0029]** According to the present application. it is possible not only to optimise the vulcanisation in accordance with the different compound rubbers. but also to prevent excessive or insufficient vulcanisation based on variations in thickness of the rubber components.

**[0030]** More specifically. in previous systems the vulcanising time of a tyre is usually set such that the tread Tt which has the greatest tyre thickness is not insufficiently vulcanised but the side walls Ts which largely contribute to the performance of the tyre particularly in respect of rolling resistance have the smallest thickness and thus are excessively vulcanised. and characteristics of both are not fully obtained. By the present invention reducing the temperatures of the inner and outer forming surface portions Si1. So1 corresponding to the side walls Ts so they are cooler than the temperatures of the inner and outer forming surface portions Si2. So2 corresponding to the tread Tt. it is possible to avoid excessive vulcanisation. and to allow the required tyre performance to be exhibited to the utmost.

**[0031]** For the heaters 4 and 5. it is possible to employ various heaters such as electric heater and the steam jacket as described above. and various temperature controlling methods can be used in accordance with the kind of the heaters used.

**[0032]** It is preferable that heat insulators are interposed between the inner mould pieces 16U. 16L and 17 for keeping the temperature difference between the inner forming surface portions Si1 and Si2

**[0033]** Although the tread Tt and the side walls Ts are indicated as portions of the tyre in this example. a bead can also be added. and the tyre may be divided appropriately in accordance with the kinds of the compound rubbers to be used or the thickness of the rubber.

**[0034]** To prove the invention a tyre (size of 205/60R15) having side wall compound attaching which is superior for fuel efficiency (rolling resistance) were cured using the vulcanising apparatus shown in Fig. 1 The heaters 4U. 4L. 4M of the outer mould 2 and the heaters 5U. 5L. 5M of the inner mould 3 were controlled at different temperatures based on the specifications shown in Table 1 and the fuel efficiency of the finished tyre was measured. The temperature of the tyre at its side which was in contact with each of the forming surface portions (a surface portion corresponding to a forming surface portion in a comparative example) during vulcanising was measured. and its results are shown in Table 1.

**[0035]** Further. as a second comparative example. a tyre was vulcanised and formed in the conventional steam vulcanising method shown in Fig. 5 in which steam of 14 kgf/cm$^2$ was charged into the bladder. The fuel efficiency of the finished tyre was measured and compared with the first test. In the comparative example. the temperature was controlled from outside the tyre as in the same manner as that of the present embodiment by heaters 4U, 4L and 4M.

**[0036]** Each of tyres were mounted on a standard rim. the rolling resistance was measured at standard internal pressure at 80 km/hr at load of 400 kgf using a rolling resistance testing machine. and the fuel efficiency as indicated as an index with the comparative tyre set at 100. The fuel efficiency is better as the index is smaller.

Table 1

| | Example | Comparative Example |
|---|---|---|
| Heaters of outer mould<br>Set temperature (degrees) | | |

Table 1 (continued)

| | Example | Comparative Example |
|---|---|---|
| 4U | 165 | 165 |
| 4L | 165 | 165 |
| 4M | 180 | 180 |
| Heaters of inner mould | | |
| Set temperature (degrees)* | | |
| 5U | 165 | 185 |
| 5L | 165 | 175 |
| 5M | 180 | 180 |
| Temperature (degrees) of tyre at the side of outer forming surface portion | | |
| Si1 (Up) | 160 | 160 |
| Si1 (Down) | 160 | 160 |
| Si2 | 170 | 170 |
| Temperature (degrees) of tyre at the side of inner forming surface portion | | |
| Si1 (Up) | 165 | 185 |
| Si1 (Down) | 165 | 175 |
| Si2 | 180 | 180 |
| Vulcanising time (minutes) | 13 | 13 |
| Fuel efficiency (index) | 96 | 100 |

* Steam temperature in steam vulcanising method in the case of the comparative example

**[0037]** As shown in Table 1. it was confirmed that in the present embodiment. since the vulcanising temperature at the side walls Ts was suppressed. excessive vulcanisation was prevented. and the fuel efficiency was enhanced.

**[0038]** As described above. according to the present invention. since the heating temperatures are varied from inside the tyre in accordance with portions of the tyre using an inner mould which forms an inner surface of the tyre. it is possible to vulcanise each of the portions of the tyre under optimal temperature condition without generating uneven temperature between upper and lower portions. and it is possible to enhance the performance of the tyre

## Claims

1. A vulcanising method for vulcanising a tyre (T) by heating from an outer forming surface (So) and an inner forming surface (Si) of a vulcanising apparatus comprising an outer mould (2) having said outer forming surface (So) for forming the outer surface of said tyre and an inner mould (3) having said inner surface (Si) for forming an inner surface of the tyre. characterised in that said inner forming surface (Si) is divided into a plurality of inner forming surface portions (Si1) in accordance with portioned of said tyre (T) along an outline of a tyre meridian cross section. and the temperatures of the inner forming surface portions (Si1) are varied to vulcanise each of said portions of the tyre.

2. A vulcanising method of a tyre according to claim 1. characterised in that the outer forming surface (So) of said outer mould is divided into a plurality of outer forming surface portions (So1) in accordance with portions of the tyre along said outline of said tyre meridian cross section. and the temperatures of said outer forming surface portions (So1) are varied to vulcanise each of the portions of the tyre.

3. A vulcanising apparatus for a tyre comprising an outer mould (6) having an outer forming surface (So) for forming an outer surface of the tyre (T) and an inner mould (3) having an inner surface (Si) for forming an inner surface of the tyre. characterised in the that inner forming surface (So) of the inner mould (3) is divided into a plurality of inner forming surface portions (Si1) in accordance with portions of the tyre along an outline of a tyre meridian cross section. and the inner mould (3) is provided with heaters (5U.5L.5M) capable of heating the inner forming surface portions at different temperatures

4. A vulcanising apparatus of a tyre according to claim 3. characterised in that the outer forming surface (So) of said outer mould (3) is divided into a plurality of outer forming surface portions (So1) in accordance with portions of the tyre (T) along an outline of a tyre meridian cross section. and the outer mould (2) is provided with heaters capable of heating the outer forming surface portions (So1) at different temperatures.

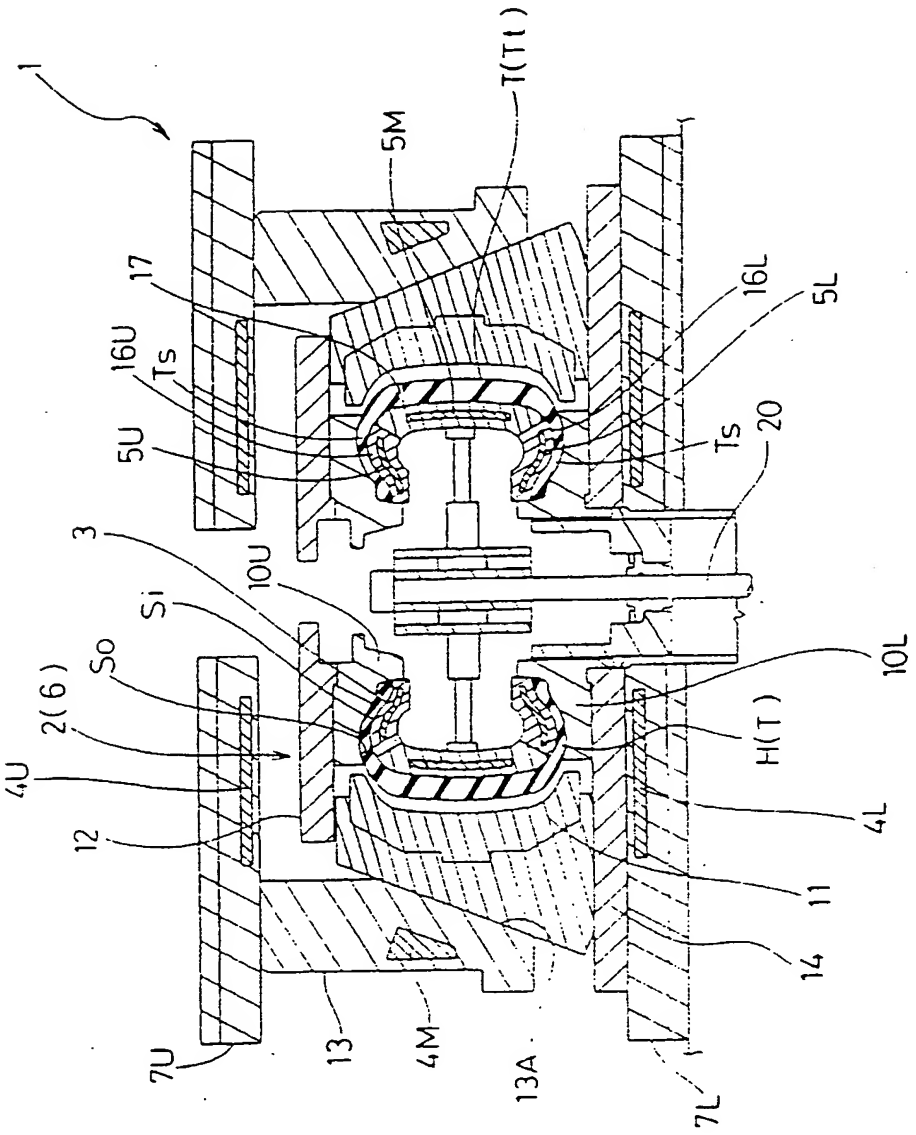



Fig. 1

Fig. 2

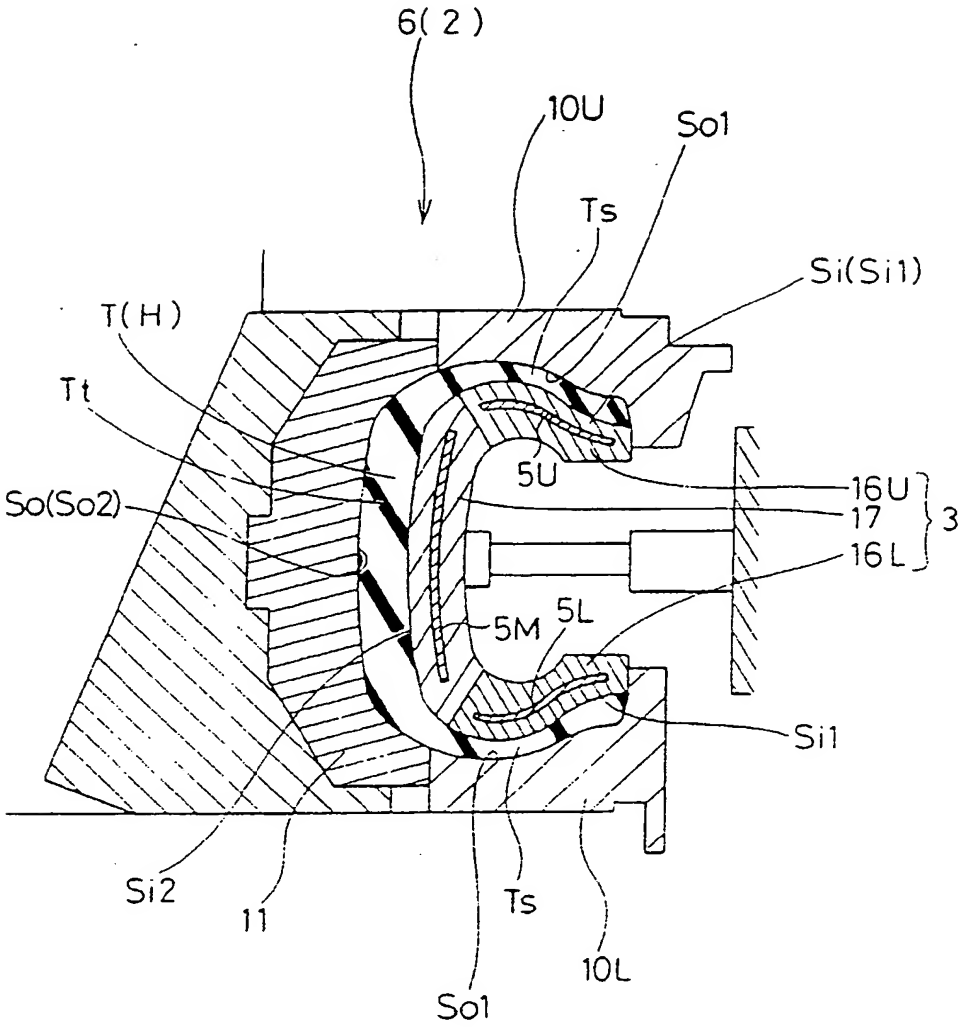


Fig. 3

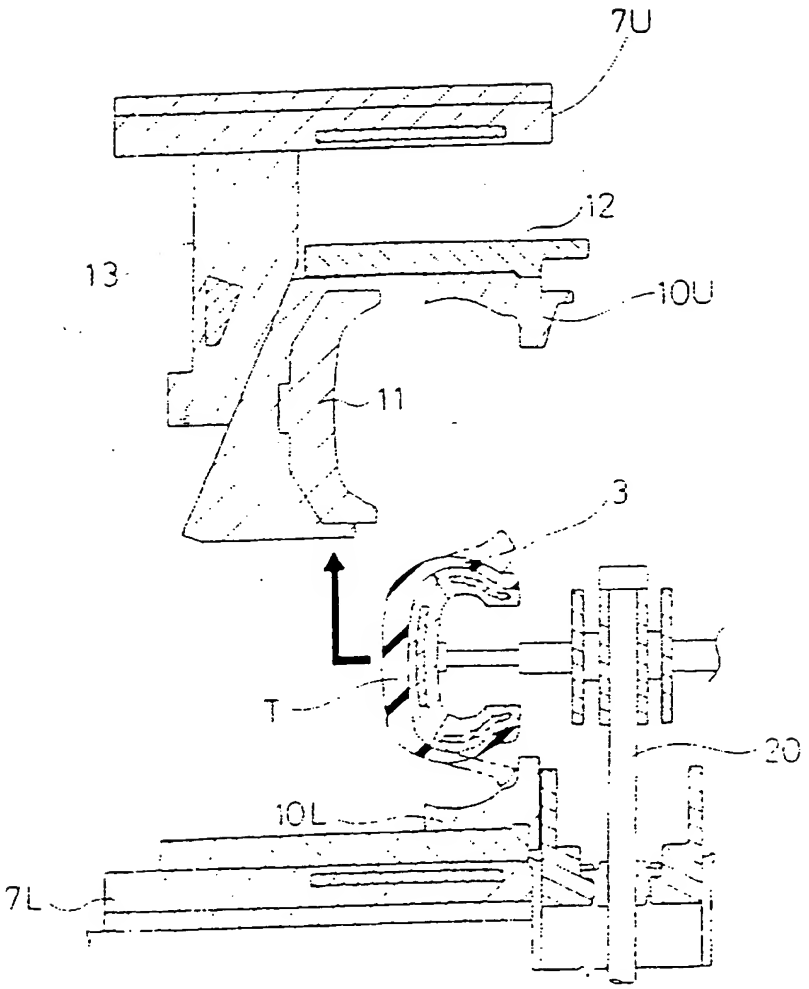
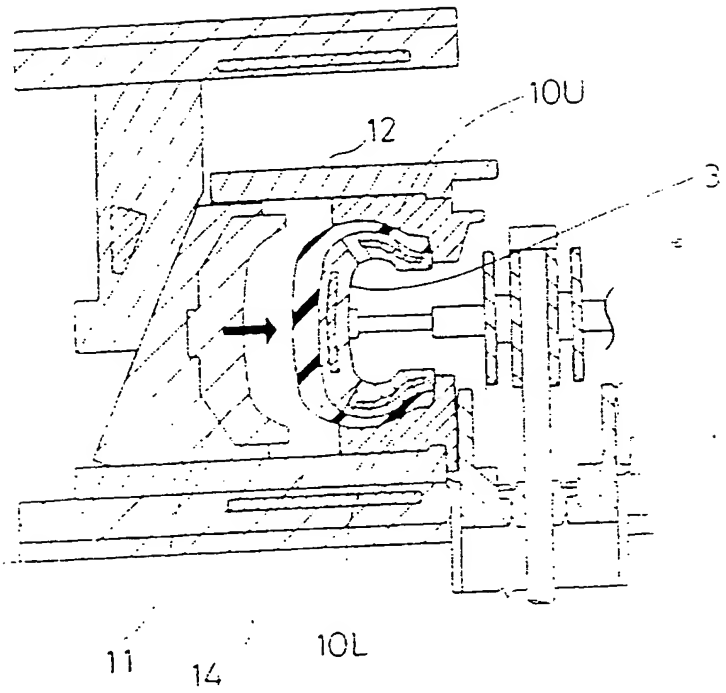


Fig. 4



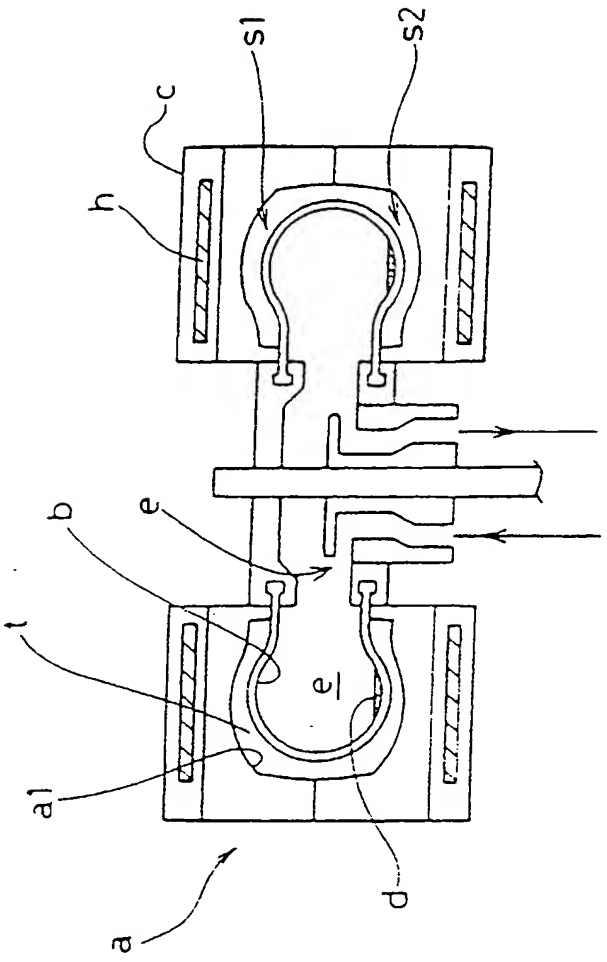



Fig. 5